

We claim:

1. A heavy oil upgrading reactor comprising:

a) a partial oxidation reaction chamber suitable for generating syngas, said syngas containing hydrogen gas;

b) a heavy oil upgrading reaction chamber including:

5 i) a high temperature reaction zone suitable for thermally cracking at least a portion of said heavy oil in the presence of said syngas at a temperature in excess of 1225°F for less than 10 seconds to form a thermally cracked oil;

10 ii) a rapid quench zone suitable for quenching the thermally cracked oil with a heavy oil quench within 10 seconds of the initiation of said thermal cracking of said heavy oil in said high temperature reaction zone;

15 iii) a stabilization zone suitable for providing a residence time for said thermally cracked oil of from 1 to 60 minutes at a reduced temperature below 850°F to form an upgraded oil mixture; and

20 iv) one or more eduction nozzle(s) suitable for receiving said syngas formed in said partial oxidation reaction chamber, said syngas flowing through said eduction nozzle at a velocity sufficient to educe heavy oil from said heavy oil reaction chamber into said eduction nozzle thereby contacting said syngas with at least a portion of said heavy oil; and

c) a passage suitable for withdrawing at least a portion of said upgraded oil mixture from said heavy oil upgrading reaction chamber.

25 2. The reactor of Claim 1, wherein said high temperature reaction zone is principally located in said eduction nozzle.

3. The reactor of Claim 2, wherein said high temperature reaction zone is completely located in said eduction nozzle.
4. The reactor of Claim 3, wherein said rapid quench zone is principally located in said eduction nozzle.
- 30 5. The reactor of Claim 2, wherein said heavy oil upgrading reaction chamber is suitable for internally recycling a mixture of said thermally cracked oil and said heavy oil quench to said eduction nozzle thereby enabling multiple passes of recycled oil through said high temperature reaction zone of said heavy oil upgrading reaction chamber.
- 35 6. The reactor of Claim 5, wherein said reactor eduction nozzle is suitable for passing greater than 10 units of oil through said nozzle for each unit of fresh heavy oil feed entering said heavy oil upgrading reaction chamber.
7. The reactor of Claim 2, wherein said partial oxidation reaction chamber contains an oxidizing agent feed passage suitable for passing an oxidizing agent composed predominantly of air into said partial oxidation reaction chamber.
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8. The reactor of Claim 2, wherein said heavy oil upgrading reaction chamber is suitable for operating at an internal pressure of 200 to 600 psig.
9. The reactor of Claim 8, wherein said heavy oil upgrading reaction chamber is suitable for operating at a hydrogen gas partial pressure of from 40 to 120 psia.
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10. The reactor of Claim 2, wherein said stabilization zone is suitable for providing a residence time for the thermally cracked oil of from 20 to 50 minutes.
- 50 11. The reactor of Claim 2, wherein said high temperature reaction zone is suitable for thermally cracking at least a portion of said heavy oil in the

presence of said syngas at a temperature in excess of 1225°F for less than 2 seconds.

- 55 12. The reactor of Claim 2, wherein said reactor contains a plurality of eduction nozzle conduits.
13. A heavy oil upgrading process, said process producing 80 wt.% or greater of liquid products, said process comprising:
- 60 a) thermally cracking a feed oil comprising heavy oil at a temperature above 1225°F for less than 10 seconds in the presence of a hydrogen-containing gas to produce a thermally cracked oil product;
- b) quenching said thermally cracked oil product within 10 seconds of the initiation of said thermal cracking of said feed oil by mixing said thermally cracked oil product with a quench oil to form a quenched oil product; and
- 65 c) stabilizing the quenched oil product at a temperature below 850°F for from 1 to 60 minutes to form a stabilized oil product.
14. A process according to Claim 13, wherein said thermally cracking step's duration is less than 2 seconds.
15. A process according to Claim 14, wherein said thermally cracking step is predominantly a gas phase thermal cracking reaction.
- 70 16. A process according to Claim 15, wherein said quench oil comprises heavy oil.
17. A process according to Claim 16, further including providing a fresh feed stream of heavy oil to said process at a first mass flow rate.
- 75 18. A process according to Claim 17, wherein the feed oil provided to said thermal cracking step (a) comprises recycled quenched oil product and/or stabilized oil product.

19. A process according to Claim 18, wherein the total mass flow rate of feed oil provided to said thermal cracking step (a) is at least 10 times greater than said first mass flow rate of said fresh feed stream.
- 80 20. A process according to Claim 16, wherein heavy oil is upgraded to lighter oil in both said thermal cracking step (a) and in said stabilization step (c).
21. A process according to Claim 20, wherein at least 30 percent of the total upgrading of said heavy oil occurs in said stabilization step (c).
22. A process according to Claim 16, wherein said process produces less than 4
85 weight percent of C₁ to C₄ hydrocarbons.
23. A process according to Claim 22, wherein said process produces less than 1 weight percent of C₁ to C₄ hydrocarbons.
24. A process according to Claim 16, wherein said quenched oil product is stabilized for from 20 to 50 minutes.
- 90 25. A process according to Claim 16, wherein said hydrogen-containing gas is syngas produced primarily from air as an oxidizing agent, said syngas containing hydrogen gas.
26. A process according to Claim 25, wherein said thermal cracking step (a) is conducted at a system pressure of 200 to 600 psig.
- 95 27. A process according to Claim 26, wherein said thermal cracking step (a) is conducted at a hydrogen gas partial pressure of from 40 to 120 psia.
28. A process according to Claim 27, wherein said syngas production further includes the use of steam and a hydrocarbon gas, said steam to hydrocarbon gas molar ratio being from 0.5:1 to 2.0:1.
- 100 29. A process according to Claim 16, wherein said process produces less than 1.0 wt.% of coke on a fresh feed oil basis.

30. A process according to Claim 29, wherein said process produces less than 0.5 wt.% of coke on a fresh feed oil basis.
31. A process according to Claim 30, wherein said process produces less than 0.1 wt.% of coke on a fresh feed oil basis.
32. A process according to Claim 16, wherein said process produces 1050°F conversion of greater than 30 wt.%.
33. A process according to Claim 32, wherein said process produces 1050°F conversion of greater than 35 wt.%.
34. A process according to Claim 16, wherein the reaction severity index (RSI_{875°F}) of said stabilizing step is below 300 seconds.
35. A process according to Claim 16, wherein the reaction severity index (RSI_{875°F}) of said stabilizing step is below 200 seconds.
36. A process according to Claim 16, wherein said process produces 90 wt.% or greater of liquid products.
37. A process according to Claim 36, wherein said process produces 95 wt.% or greater of liquid products.
38. A process according to Claim 16, wherein said process is a non-catalytic process.
39. A process according to Claim 16, wherein said feed oil includes up to 5 wt.% of solids.
40. A process according to Claim 16, further including :
d) separating from said stabilized oil product a heavy oil fraction and recycling said heavy oil fraction to said thermal cracking step (a).
41. A stabilized oil product made by the process of Claim 13.